PATENT SPECIFICATION 948,648

DRAWINGS ATTACHED.

948,648

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COMPLETE SPECIFICATION.

Improvements in or relating to Signal Recording Devices.

We, PHILIPS ELECTRICAL INDUSTRIES LIMITED, of Abacus House, 33 Gutter Lane, London, E.C.2, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the recording of wide frequency band signals in a magnetic layer provided on a moving tape or other carrier, and has for its object to provide a device for this purpose which records all the frequencies of the spectrum to be recorded with good amplitude and low frequency-distortion.

For this purpose, a recording head according to the invention has a gap length which varies either continuously or discontinuously across at least part of the signal track, so that in any cross-section of the magnetic layer at right angles to the direction of motion of the carrier, a zone is provided for substantially optimum recording of each of the different frequency components of the signal.

If, as is common, a high frequency auxiliary field is used for the recording, this auxiliary field may be distributed in the gap so that, within the magnetic layer in any plane parallel to the surface of the layer, the strength of the auxiliary field varies continuously across at least a part of the width of the track.

This variation in strength of the auxiliary field may be brought about by producing a local auxiliary field in the gap of the recording head, preferably either by providing a conductive spacing member in this gap, the height and/or the thickness of which varies in the direction of the width of the gap, or by providing an auxiliary winding around a part of the magnetic circuit of the head, which winding is either tuned to the frequency of the auxiliary field, or is fed with this frequency by an auxiliary generator with such phase that the auxiliary field is locally attenuated by the auxiliary winding.

Within the range in which the strength of the auxiliary field fluctuates about the coercive field strength, phase variation of the signal field occurs. This might produce a serious attenuation, particularly of the high frequencies. The invention also provides, in one form thereof, means for limiting this attenuation.

One means for this purpose uses a recording head provided with two gaps, one behind the other in the direction of motion of the carrier, the first of which produces the auxiliary field, and the second of which provides the signal field. The auxiliary field is then distributed in these two gaps so that, at the end of the second gap, the auxiliary field shows a strong gradient.

This variation in strength of the auxiliary field may be obtained either by providing the gap of the auxiliary field at a small inclined angle with respect to the signal gap, or by varying the length and/or the height of the gap for the auxiliary field in the direction of width of the track.

In one embodiment, a double gap in the recording head is avoided and a marked gradient of the auxiliary field is nevertheless provided in the immediate proximity of the trailing edge of the single gap, by providing the recording head with an auxiliary pole on the side of the carrier opposite the gap. The distance to that gap of this pole varies in the direction of width of the track and the distribution the auxiliary field in this pole and in the gap is such that the auxiliary field shows a

strong gradient in the proximity of the trailing edge of this gap.

In yet another embodiment, a preferably movable, auxiliary head with gap is provided opposite to the recording head on the other side of the carrier, the auxiliary field being distributed between the two heads so that it shows a strong gradient in the proximity of the trailing edge of the signal gap. In this embodiment, a varying strength of the auxiliary field across the width of the track may be obtained either by arranging the gap plane of the auxiliary head obliquely to the direction of motion of the carrier or by arranging the side of the auxiliary head, facing the carrier, obliquely to the surface of the carrier.

In order that the invention may be readily carried into effect, some embodiments thereof will now be described in detail, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a known circuit arrangement by which the frequency band of a signal to be recorded can be divided into parts;

Figure 2 is a graphical representation which shows the frequency characteristics of the divided parts;

Figure 3 shows a magnetic carrier with two sound tracks and associated recording and playback heads;

Figure 4 shows methods by which the gap length of a head may be varied in the direction of width thereof;

Figures 5 and 6 show diagrammatically two different ways in which the auxiliary field may be varied locally within the gap of a recording head;

Figures 7 and 8 show diagrammatically a recording head with two gaps, in which the auxiliary field varies, within one of these gaps in two different modes in the direction of width of the head;

Figure 9 shows diagrammatically a recording head having a co-operating auxiliary pole; and

Figure 10 shows a recording head and a co-operating auxiliary head provided on the other side of the magnetic carrier.

With the circuit arrangement as shown in Figure 1, an incoming audio frequency indicated by V_0 is divided into two frequency bands indicated by V_1 and V_2 respectively. Band V_1 consists substantially of the low and V_2 substantially of the higher frequencies of the incoming band. The filters used for this purpose are indicated in their simplest forms by R—C and C—R. Figure 2 shows the frequency characteristics of the two split bands V_1 and V_2 respectively.

The reason for dividing the total frequency band into two (or more) parts, lies partly in the fact that the gap length of the recording head for optimum recording generally must be chosen larger for the low than for the high audio frequencies. Also, with the simultaneously presence of high frequency and low frequency, modulation amplitude peaks easily occur which may cause saturation of the magnetic material. As a result, intermodulation occurs and also the modulation level which is to be adjusted in the recording has to remain on an average comparatively low.

When operating with a single track and a single head, one is forced to effect a compromise. When operating with two or more tracks, the conditions for each track may be chosen more favourably.

Figure 3 shows an example of a known two-track system, in which the lower frequencies are recorded in the track 5 and the higher frequencies in the track 6 of a carrier 4, by the recording heads 1 and 2 respectively. The gap length d_1 of the head 1 is larger than the gap length d_2 of the head 2. For playing back the two tracks, use may be made of two equal playing back heads 3 having gap lengths d_3, one for each track.

Apart from the additional complication, due to the required filters and separate amplifiers, the operation with two or more tracks has some practical drawbacks. The total track width becomes larger, unless narrowed tracks are used, which latter gives a less favourable signal-to-noise ratio. In addition, the gaps of the recording head, as also those of the playback heads, should be aligned accurately with respect to each other, which is not simple.

These drawbacks may be mitigated by use of the invention by recording the incoming signal entirely in one track by a recording head, the gap length of which varies across the width of the track. This variation of the gap length may be continuous or discontinuous, as is diagrammatically shown in Figure 4. The lower head 7 in this figure is a recording head having a wedge-shaped gap 8. The head 9 shown above is a recording head having a gap 10 which narrows abruptly half-way along the track width. The two heads 11, 13 shown above the heads 7 and 9 may be used for reproducing the signals recorded by either of the heads 7 or 9. For that purpose, the head 11 has a uniform short gap, while the head 13 has a tapering gap 14 which is approximately the same shape as the gap 8 of head 7.

A recording head with gap length varying across the width of the track results in the recording level for lower frequencies being higher in the parts of the track corresponding to the larger gap. A certain frequency separation thus takes place

which is the result of the variation of the geometric configuration of the recording head in a direction at right angles to the direction of motion of the carrier.

The shapes of the gaps shown in Figure 4 are given by way of example only and it will be clear that the variation of the gap length may be realised in a large number of different manners. However, in all cases the shape of the gap at the trailing edge, that is to say the side where the carries moves away from the gap, should be exactly the same for both the playback and the recording heads. Only then is the exact azimuth for the high frequencies ensured.

In the further means described with reference to Figures 5 to 10, a high frequency auxiliary field, as normally used in magnetic tape recording, is used. It is required to give this auxiliary field a distribution so that, within the magnetic recording layer, in any plane parallel to the surface of that layer, the strength of the auxiliary field varies continuously across the width of the track. The idea underlying this method briefly is as follows.

When recording sinusoidal signals on a strength of the high frequency auxiliary moving magnetic carrier, the optimum current, with respect to the intensity and the distortion of the signal recorded, depends on the wavelength to be recorded. Thus, the optimum strength increases with increasing wavelengths i.e. with decrease of frequency. With wavelengths which are large with respect to the thickness of the magnetic layer, the entire thickness of the layer is used and the maximum playback output will be obtained when the strength of the high frequency auxiliary field in the middle of the layer has the most favourable value. With smaller wavelengths, the magnetisation of the deeper-situated layers plays not part, as a result of the internal demagnetising fields and the distance effect. It is desirable, for these short waves, to give the auxiliary field the most favourable strength in a layer close to the surface, facing the head. A study of the distortion results in corresponding requirements for the auxiliary field. As regards the long waves, in a curve representing third harmonic distortion as a function of the intensity of the auxiliary current, a significant minimum will occur if the strength of the auxiliary field in the middle of the layer has the above-mentioned favourable value. This probably results from compensation of third harmonics produced in surface layers by third harmonics of opposite sign in deeper-situated layers. With shorter wavelength, this compensation will be disturbed by the decreasing influence of deeper-situated layers.

In the past, it has been impossible for the low frequencies, to adjust the auxiliary field so that the high frequencies are not attenuated to a considerable extent. The above particular distribution of the auxiliary field in the gap of the recording head mitigates this draw back. By this distribution, an optimum zone for each frequency band to be recorded, and particularly for the high frequencies, may be provided. In this zone, the auxiliary field is optimal and the frequency in question is recorded with maximum amplitude. The third harmonic distortion is low in the entire frequency range, since the compensation of third harmonics in this case is not dependent upon the co-operating field of surface layers and deeper-situated layers, but is effected independently of the wavelength by the co-operating influence of various parts of the track width.

To realise such a distribution, a recording head with a single gap may be used in which locally an auxiliary field of suitable strength variation is produced. This auxiliary field may be a result, for example, of eddy currents in the material with which a gap is wholly or partially filled. In order to obtain the desired variation in the direction of width, a conductive non-ferrous spacer may be used which in thickness and height varies across the width of the head. Such a spacer is indicated by 15 in Figure 5. A similar, but ferrous, wedge-shaped spacer 27 is also included with the spacer 15 between the poles 28, 29 so as to leave gaps 30, 31, on either side of the spacers.

Another possibility is shown in Figure 6. In this case, an auxiliary winding 16, in the proximity of the gap 17, encloses a part of the cross-sectional area of the magnetic circuit of the recording head 18. The ends of this winding are connected either to a suitable impedance as a result of which only the high frequency auxiliary fields causes induction currents to flow in the auxiliary winding, while the signal field passes unhindered, or to a high frequency secondary field generator of suitable phase. The latter method offers the advantage that the variation of the auxiliary field is capable of being made adjustable in the direction of width of the head and may be adapted to the speed of the medium or to the nature of the magnetic layer.

In the above realisation of the invention, the recording of high frequencies is possibly restricted by the phase variation of the signals during the recording process. This process takes place in a range in which the strength of the auxiliary field is

in a critical zone around the coercive field strength. According as this range is larger and the frequency of the signal higher, the phase of the signal will change more during the recording, with loss of strength as a result. It is consequently of importance that the gradient of the strength of the auxiliary field, directly after passing the gap, is as large as possible.

Still another condition to which attention should be paid when recording is that the strength with which the recorded signal may be reproduced is determined particularly by the longitudinal magnetisation and far less by the magnetisation at right angles in the magnetic layer of the carrier. This latter magnetisation is produced close to the surface of the layer by the signal.

To provide a high gradient auxiliary field and the desired longitudinal magnetisation, use may advantageously be made of the co-operating fields of two gaps situated one behind the other, seen in the direction of motion of the medium.

A recording head to be used in this case is diagrammatically shown in Figures 7 and 8. The first gap 19, seen in the direction of motion of the carrier as indicated by arrow 32, mostly produces the auxiliary field. Recording is effected at the signal gap 20 where the signal field is directed longitudinally. By exact distribution of the auxiliary field between the two gaps a stronger gradient of the auxiliary field for the signal gap may be achieved. The desired variation of the high frequency auxiliary field across the width of the track may be effected either by arranging the auxiliary field gap 19 out of parallel with the signal gap 20, as shown in Figure 7, by varying the auxiliary field gap 21 across the direction of width of the head in length and in height, as shown in Figure 8, or by using either of the previously-mentioned methods employing a conductive spacer or auxiliary winding.

Another possibility, diagrammatically shown in Figure 9, consists in providing an auxiliary pole 22 behind the magnetic carrier opposite a recording head using a single gap. By distributing the auxiliary field in a suitable manner in the auxiliary pole and the signal gap, a strong field gradient for the signal gap may be obtained. The strength of that field may be varied across the width of the track by causing the distance between head and auxiliary pole to vary in the direction of width, as shown in Figure 9.

In the device shown in Figure 9, it is rather difficult to provide the carrier in the narrow passage between the head 23 and the fixed auxiliary pole 22. Simpler in this respect is the device shown in Figure 10, in which two heads 24 and 25 are provided on either side of the magnetic carrier 26. The head 24 mainly produces the signal field and the head 25 mainly the auxiliary field. A strong auxiliary field gradient for the signal gap can be obtained in this case also by distributing the auxiliary field in a suitable manner in the two gaps. The auxiliary field head 25 may be made movable, so that threading the magnetic carrier between the two heads need present no difficulties. The desired variation of the auxiliary field across the width of the track may be effected, as shown, by varying the distance between the two heads across the width of the track, either by providing the gap plane of the auxiliary field head obliquely to the direction of motion or by using one of the above methods.

WHAT WE CLAIM IS:—

1. A device for recording signals having a wide frequency band in a magnetic layer provided on a moving tape or other carrier, in which the gap length of the recording head varies either continuously or discontinuously across at least part of the signal track, so that in any cross-section across the magnetic layer at right angles to the direction of motion of the carrier a zone is available for each of the different frequency components of the signals within which zone the recording conditions for the components in question are at least substantially optimal.

2. A device as claimed in Claim 1, in which a high frequency auxiliary field is used for recording the signals, having a distribution of the auxiliary field in the gap or the gaps of the recording head so that within the magnetic layer in any plane parallel to the surface of that layer, the strength of the auxiliary field varies continuously across the width of the track to be recorded, at least across a part of that width.

3. A device as claimed in Claim 2, in which within the gap of the recording head a local auxiliary field is produced.

4. A device as claimed in Claim 3, in which within the gap a conductive spacing member is provided, the height and/or the thickness of which varies in the direction of the width of the gap.

5. A device as claimed in Claim 3, in which an auxiliary winding is provided around part of the magnetic circuit of the head, which winding is either tuned to the frequency of the auxiliary field, or is fed by an auxiliary generator of this frequency such phase that the auxiliary field is locally attenuated by the auxiliary winding.

6. A device as claimed in any of the Claims 2 to 5, in which the recording

head is provided with two gaps arranged one behind the other in the direction of motion of the carrier, the first of which mainly produces the auxiliary field and the second mainly the signal field, the auxiliary field being distributed between these two gaps so that the auxiliary field shows a strong gradient at the last gap.

7. A device as claimed in Claim 6, in which the gap of the auxiliary field is provided at a small inclined angle with respect to the signal gap.

8. A device as claimed in Claim 6, in which the length and/or the height of the auxiliary field vary in the direction of width of said gap.

9. A device as claimed in any of the Claims 2 to 5, in which the recording head is provided with an auxiliary pole which is provided on the side of the carrier opposite to the gap, the distance of which, to that gap, varies in the direction of width of the gap and the auxiliary field is distributed between this pole and the gap so that the auxiliary field shows a strong gradient at the trailing end of this gap.

10. A device as claimed in any of the Claims 2 to 5 in which a preferably movable auxiliary head with gap is provided opposite to the recording head on the other side of the carrier, the recording head mainly producing the signal field and the auxiliary head mainly the auxiliary field, the auxiliary field being distributed between the two heads in a manner such that it shows a strong gradient at the trailing end of the signal gap.

11. A device as claimed in Claim 10, in which the gap plane of the auxiliary head is not at right angles to the direction of motion of the carrier.

12. A device as claimed in Claim 10, in which the side of the auxiliary head facing the carrier is not parallel to the surface of the carrier.

13. A device as claimed in Claim 1, constructed substantially as described herein with reference to any one of Figures 4 to 10.

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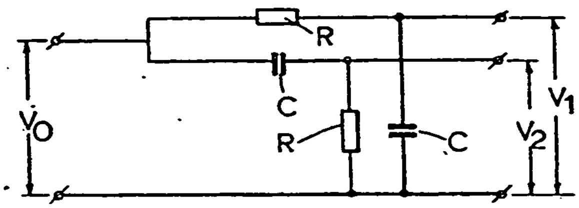

FIG.1.

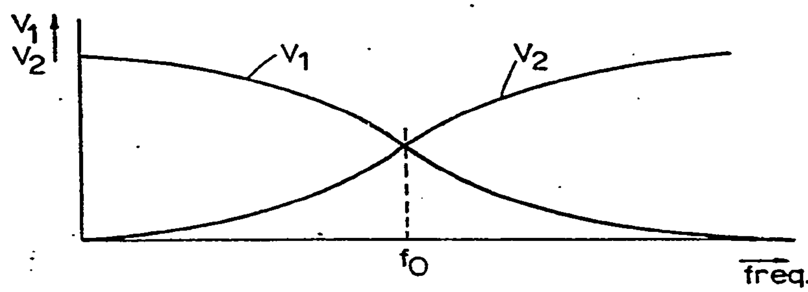

FIG.2.

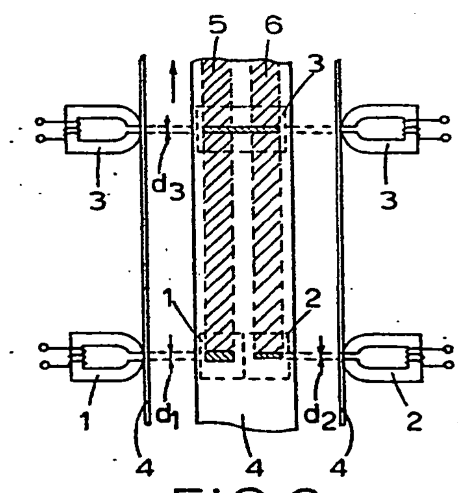

FIG.3.

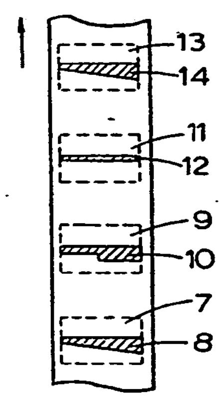

FIG.4.

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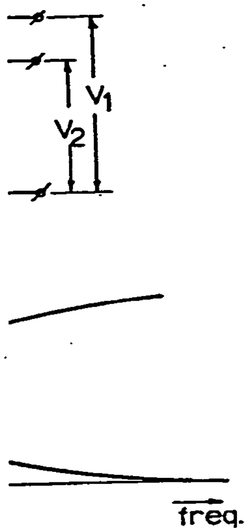
Sheets 1 & 2



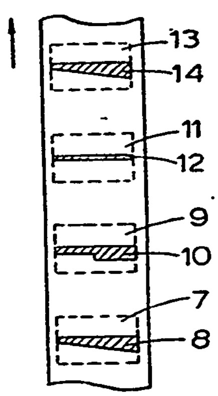


FIG.4.

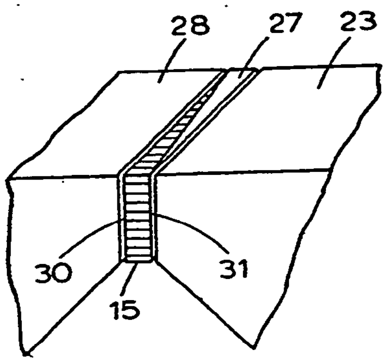


FIG.5.

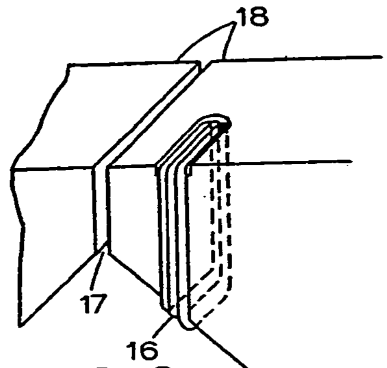


FIG.6.

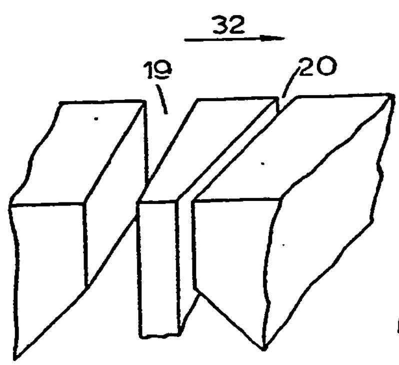


FIG.7.

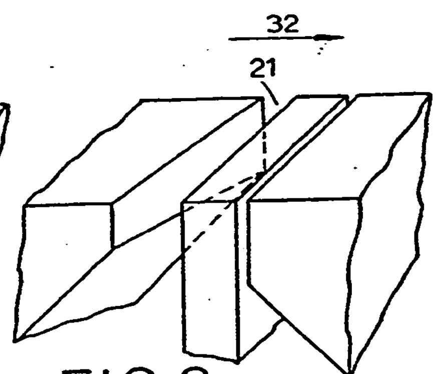


FIG.8.

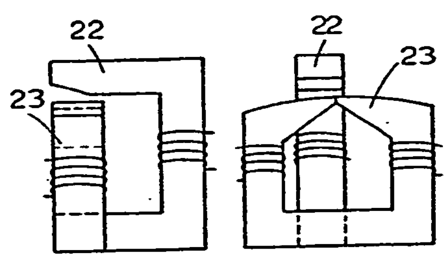


FIG.9.

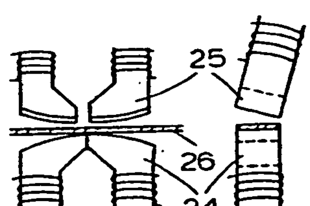


FIG.10.

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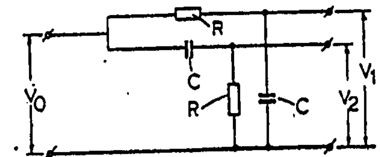

FIG.1.

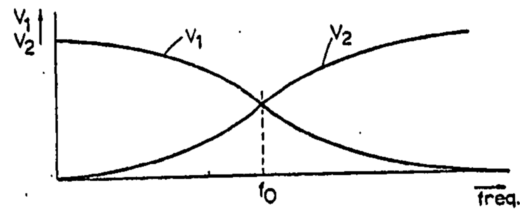

FIG.2.

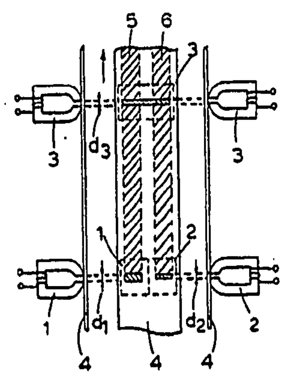

FIG.3.

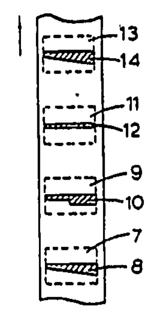

FIG.4.

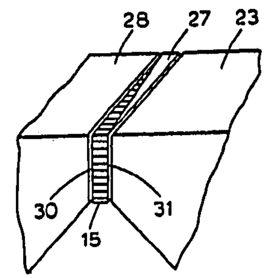

FIG.5.

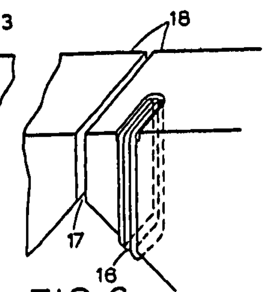

FIG.6.

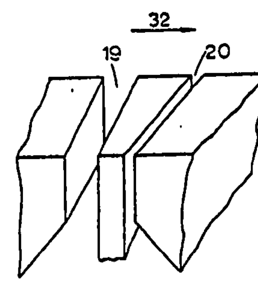

FIG.7.

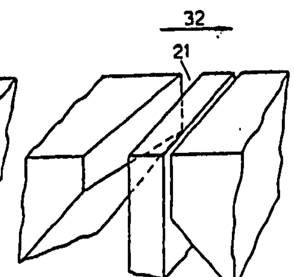

FIG.8.

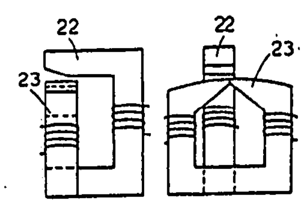

FIG.9.

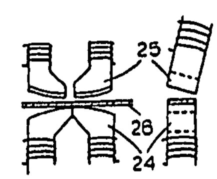

FIG.10.